Sentient Science - A Multiscale Modeling Suite for Process and Microstructure Prediction in Metal Additive Manufacturing, Phase I

Completed Technology Project (2018 - 2019)

Project Introduction

In response to NASA’s topic T12.02 of “Extensible Modeling of Metallurgical Additive Manufacturing Processes”, Sentient proposes to incorporate its **DigitalClone** technique to develop a multiscale and multiphysics computational modeling suite to predict comprehensive outcomes from AM building processes, including geometrical accuracy, and resulting microstructure and defects. **Figure 1** shows the proposed framework for the multiscale modeling suite. The process model will first predict the microscale thermal evolution in respect of various parameters. The temperature results will feed a subsequent macroscale model for prediction of stress and distortion at part scale. Moreover, the predicted thermal history and distribution will feed subsequent microstructure model to further predict the micro-scale features including grain morphology and porosity. **The proposed computational modeling framework allows a comprehensive prediction and understanding of the metal AM process at multiple levels**.

In Phase I, Sentient will upgrade and demonstrate **DigitalClone**’s capability to integrate process-microstructure simulation for metal AM process. Specifically, selective laser melting of IN 718 alloy will be used for development and demonstration purposes in Phase I. AM coupons with different geometries will be fabricated by Selective Laser Melting (SLM) at different parameters. **DigitalClone** will be used to simulate all different scenarios of coupons made from IN718 alloys, and predict temperature, stress, part distortion, and grain structure. Materials characterization will be performed on the coupons to examine geometrical accuracy, microstructure, residual stress, all of which will be used to validate the **DigitalClone** model. In Phase II, different materials and AM platforms and more complex geometrical components will be tested for model validation. Additionally, close-loop optimization framework will be explored for improving geometrical design and microstructure features.

Anticipated Benefits

A successful completion of this project will lead to a robust AM modeling suite that provides accurate prediction of dimensional accuracy, microstructure, and defects in AM process. The proposed modeling suite will significantly reduce the uncertainty and conservatism in design of new AM components and processes. NASA would directly benefit from this software via virtually pre-testing the new AM component design, process effects and part quality.

The proposed modeling software will benefit several other industries incorporating AM technique, including aerospace, medical device, automotive industries. This will not only allow customers virtually evaluating the AM part qualities, more importantly, it will provide the “best solution” for customer in respect of optimizing AM design, selecting process and materials, increasing performance, reliability and durability, and reducing cost of operation the process.

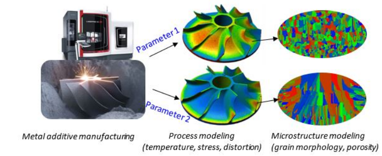

Fig. 1 Sentient’s DigitalClone modeling framework for geometrical and microstructure prediction in metal additive manufacturing.

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Small Business Innovation Research/Small Business Tech Transfer

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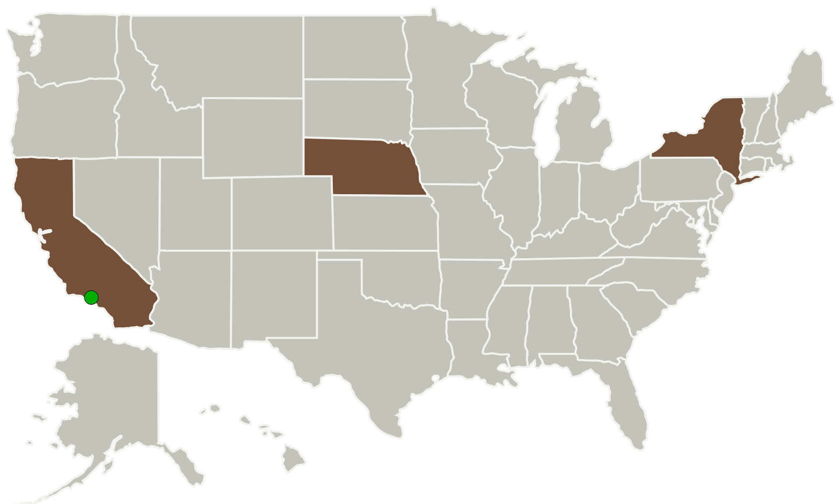
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Sentient Science	Lead Organization	Industry Historically Underutilized Business Zones (HUBZones)	Buffalo, New York
Jet Propulsion Laboratory(JPL)	Supporting Organization	NASA Center	Pasadena, California
University of Nebraska-Lincoln	Supporting Organization	Academia	Lincoln, Nebraska

Primary U.S. Work Locations	
California	Nebraska
New York	

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Sentient Science

Responsible Program:

Small Business Innovation Research/Small Business Tech Transfer

Project Management

Program Director:

Jason L Kessler

Program Manager:

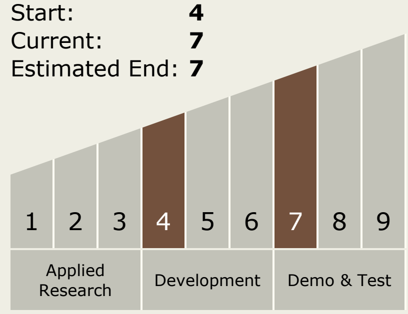
Carlos Torrez

Principal Investigator:

Jingfu Liu

Technology Maturity (TRL)

Start: **4**
Current: **7**
Estimated End: **7**



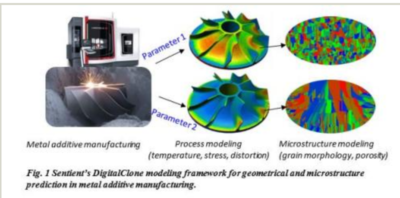
Project Transitions

July 2018: Project Start

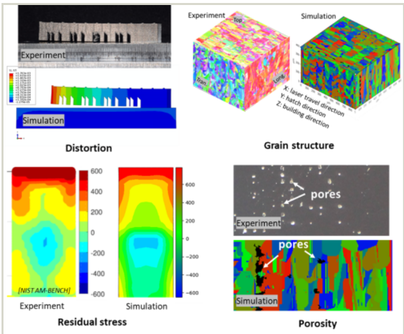
August 2019: Closed out

Closeout Documentation:
- Final Summary Chart*(https://techport.nasa.gov/file/137902)*

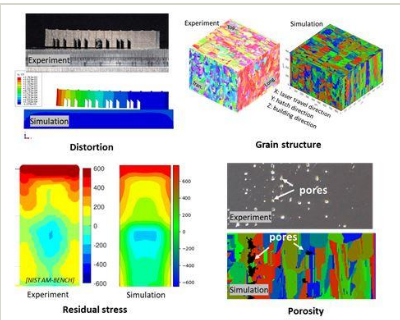
Images



Briefing Chart Image
Sentient Science - A Multiscale Modeling Suite for Process and Microstructure Prediction in Metal Additive Manufacturing, Phase I
(https://techport.nasa.gov/image/132704)



Final Summary Chart Image
Sentient Science - A Multiscale Modeling Suite for Process and Microstructure Prediction in Metal Additive Manufacturing, Phase I
(https://techport.nasa.gov/image/125911)



Final Summary Chart Image
Sentient Science - A Multiscale Modeling Suite for Process and Microstructure Prediction in Metal Additive Manufacturing, Phase I
(https://techport.nasa.gov/image/125753)

Technology Areas

Primary:

- TX12 Materials, Structures, Mechanical Systems, and Manufacturing
  └ TX12.1 Materials
    └ TX12.1.2 Computational Materials

Target Destination

Earth